Instrumentation Developments for the 2015 RHIC Run

M. Minty, with inputs from many groups

E-Lens	electron backscattering detector monitoring of the electron beam longitudinal profile new instrumentation wheel new transverse bunch-by-bunch dampers
Polarimetry	RHIC jet, RHIC CNIs, 200 MeV polarimeter
Upgrades for higher beam power	new RHIC masks RHIC abort kicker upgrade RHIC beam dump upgrade
pp2pp and Roman Pot upgrade	
AGS e-IPMs	
Instrumentation for Beam Tests that will run in parallel - BLIP raster upgrade, ERL, CeC PoP are imminent - LEReC	

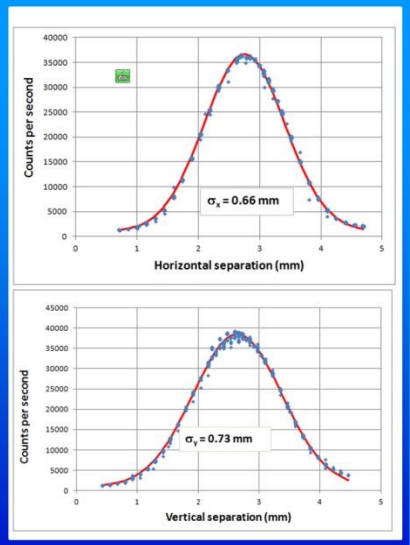
E-Lens: electron back-scattered detector (eBSD)

FY14 – concept demonstration with three applications:

1) beam overlap detector

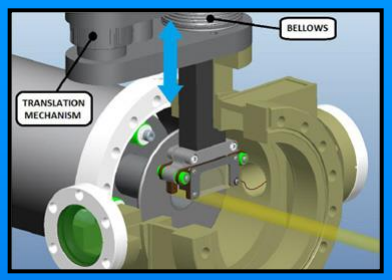
Proof-of-principle electron-gold eBSD "luminosity" scans

Date:	4/15/2014
Ion Beam:	Gold
Beam energy:	100 GeV/u
Bunch intensity:	$7*10^8$
# of bunches:	2
Solenoid Field:	2T
Electron energy:	6 keV
e-beam current:	0.565 A

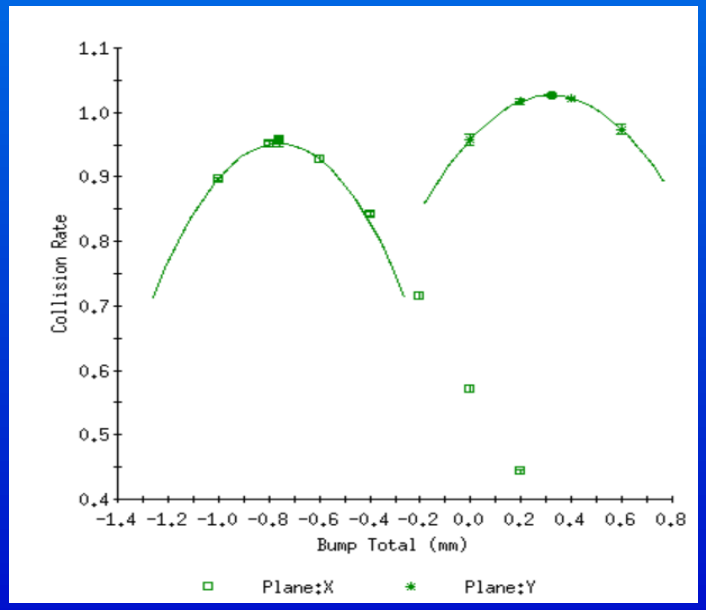


P. Thieberger et al, "The electron backscattering detector, a new tool for the precise mutual alignment of the electron and ion beams in electron lenses", IBIC 2014 (Sept, 2014)

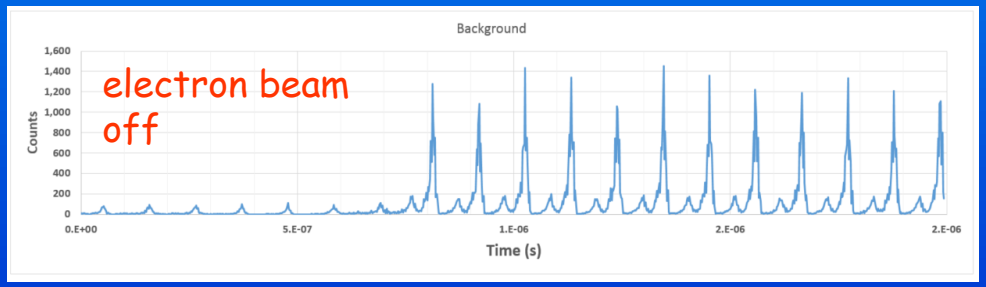
P. Thieberger et al

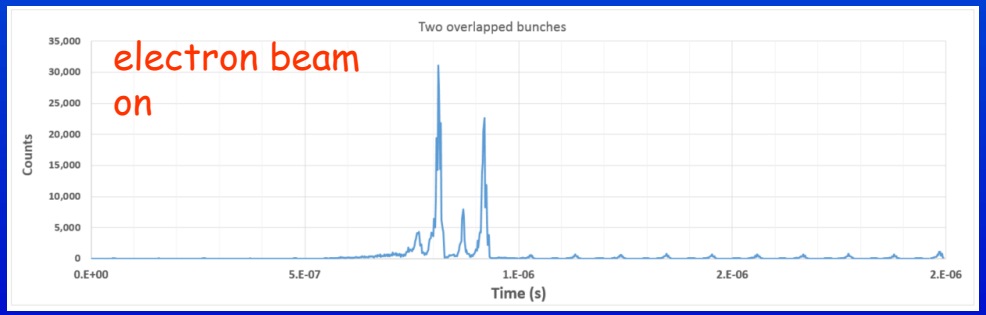


2) optimization with LISA



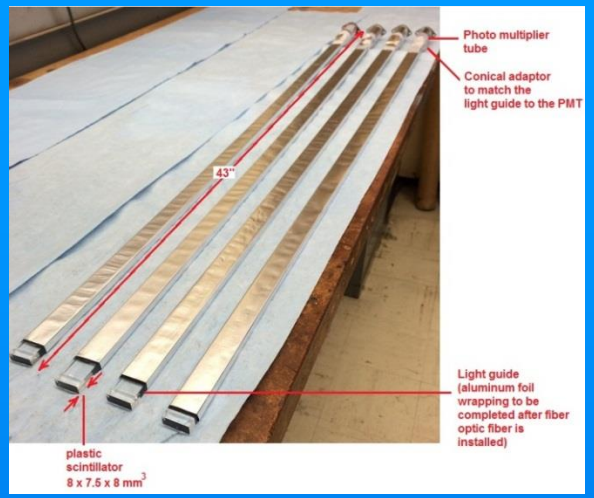
3) overlap pattern display



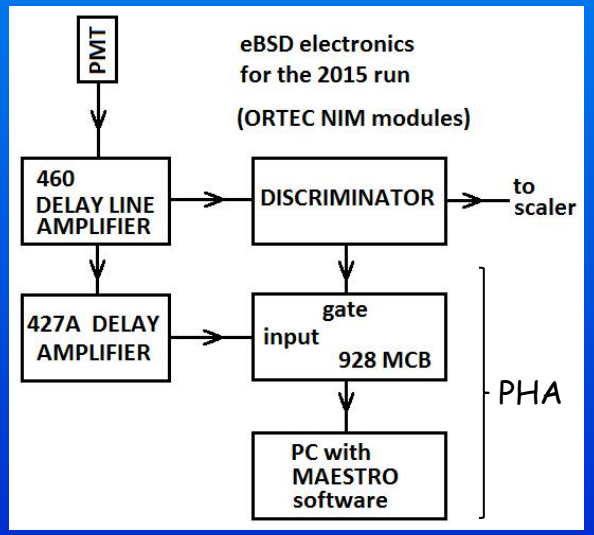


FY15 – eBSD progress and plans

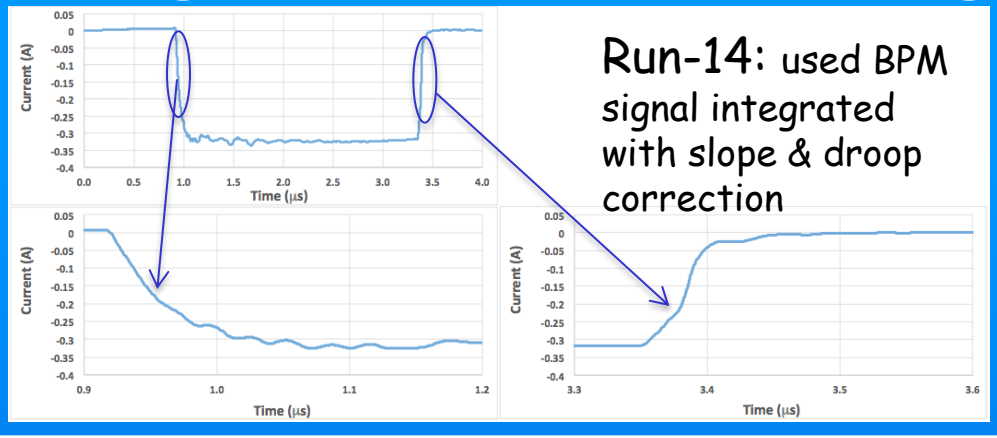
- Stiffer PMT voltage divider (to avoid rate-dependent gain)
- Assemble spare detectors, if necessary, reduce the scintillator size



- Implement pulse height analysis (PHA) for better diagnostics and optimized S/N (PMT voltage and discriminator settings)
- Make overlapped pattern display operational
- Study time-of-flight spectrum to see if it can be useful for overlap tuning
- Test and improve new LISA steering algorithms



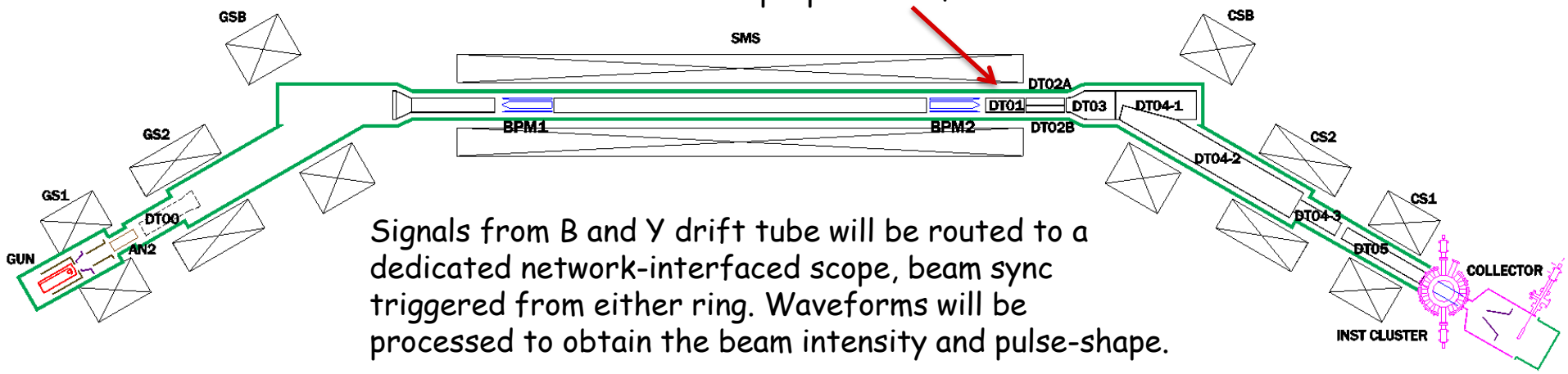
E-Lens: monitoring of the electron beam longitudinal profile



Run-14: used BPM signal integrated with slope & droop correction

P. Thieberger et al

Run-15: use repurposed drift tube



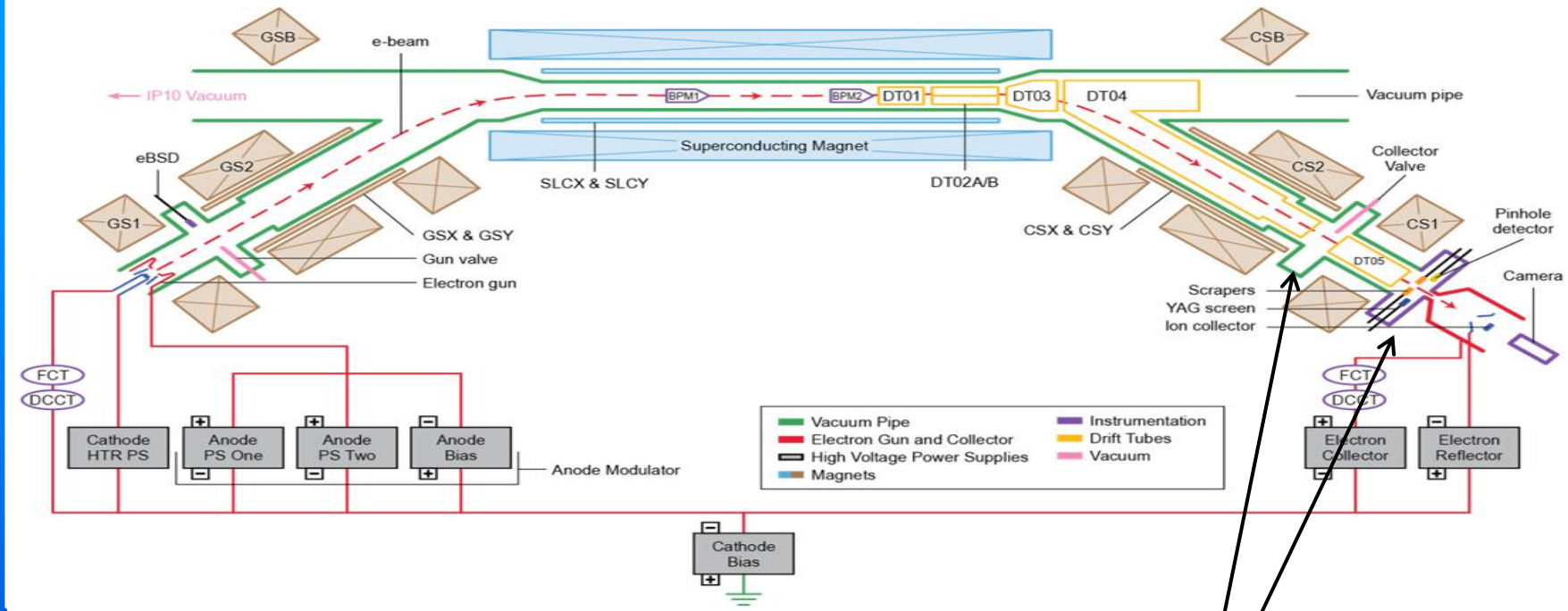
Signals from B and Y drift tube will be routed to a dedicated network-interfaced scope, beam sync triggered from either ring. Waveforms will be processed to obtain the beam intensity and pulse-shape.

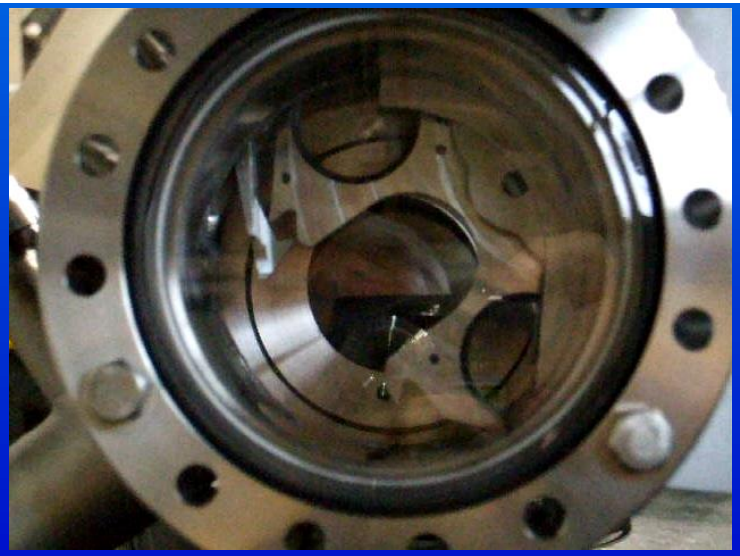
Signal processing will be done via a combination of software on the scope and in the Controls system. This will convert the BPM signals and allow data correlation and logging.

WaveRunner 604Zi DSO

E-Lens: new instrumentation wheel

From "RHIC Electron Lenses and Their Operation: An Introduction", by X. Gu et al





FY14: "instrumentation cluster" with pneumatic linear YAG, pinhole detector, etc.

FY15: + ratcheting clock type device (left) supporting up to 8 YAG screens

J. Hock, D. Lehn et al

Polarimetry: RHIC jet upgrade for FY15

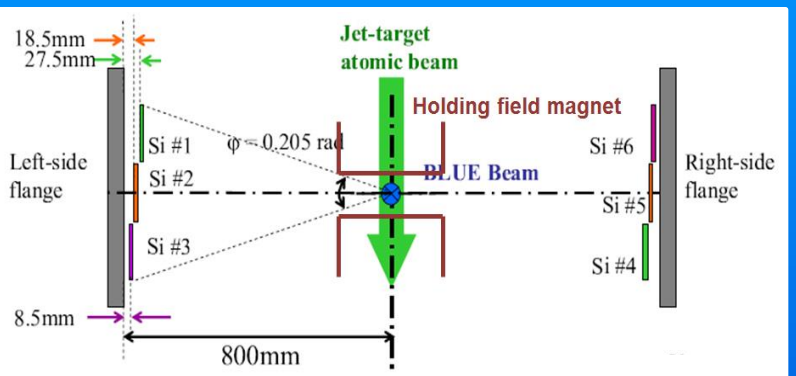
goal: reduction in measurement error

A. Zelenski et al

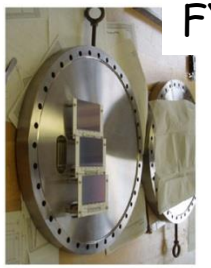
FY13: typical relative error ~ 5% for 8 hour store

FY15: with higher beam intensity and upgrade, relative error of ~ 2%
improved energy resolution, extended kinematic range

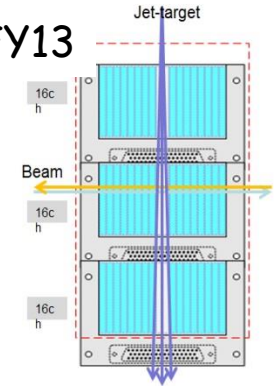
upgrade: new detectors, flanges, pre-amplifiers, DAQ

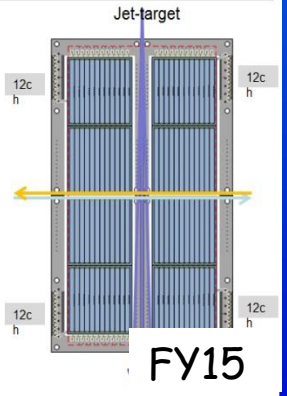


Number of strips	8	12
Strip size	4.4mm x 50mm	3.65mm x 46mm
Depletion region	400 um	500 um
Effective detector size	4.4mm x 50mm x 16 x 3 = 105.6 cm²	3.65mm x 46mm x 12 x 4 = 161.2 cm²
Entrance window thickness	Al = 1um, SiO_2 = 1um; p^+ = 1um	Al = 0.6um, SiO_2 = 0.2um; p^+ = 0.2um



FY13

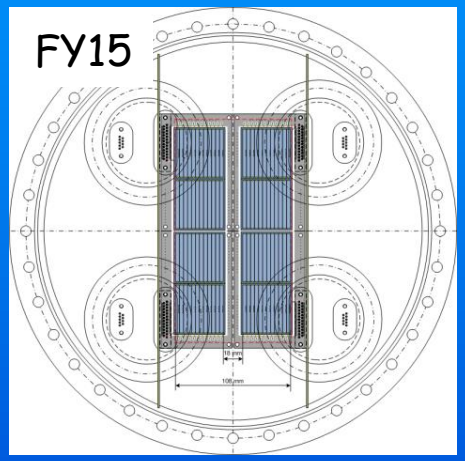




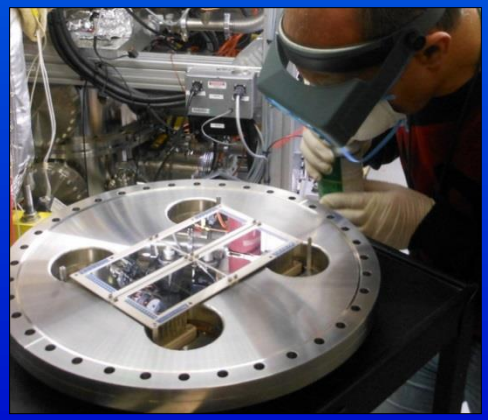
FY15

G. Atoian

Si detector layout

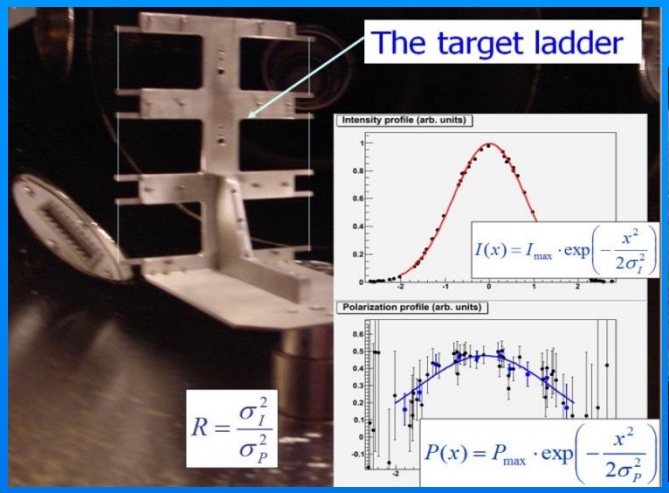


new flange and Si strip detectors



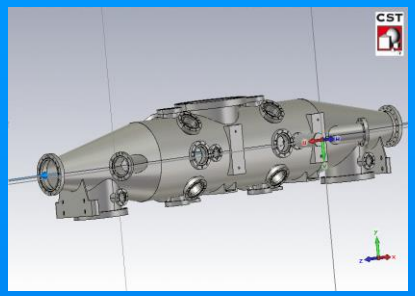
Polarimetry: RHIC CNI

FY13

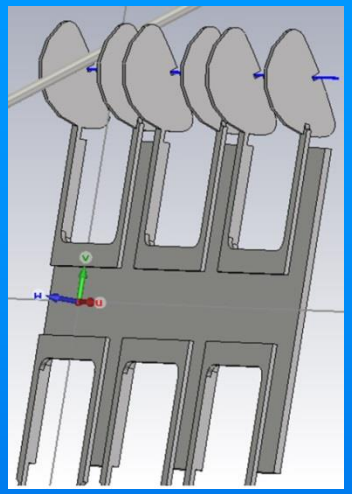


Issue - broken fibers
Observations - new imaging:

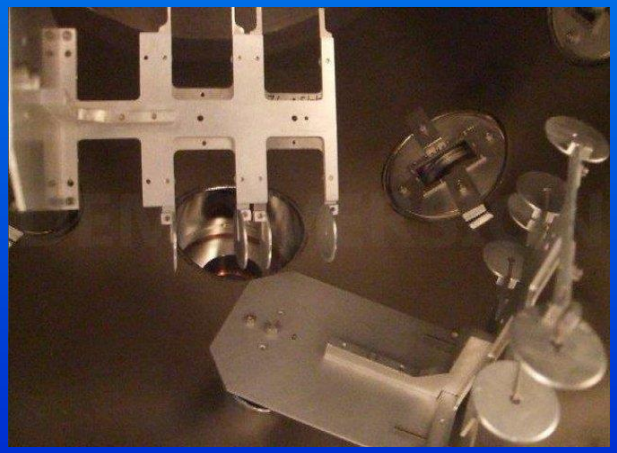
> FY13



Simulations with real chamber and long fin shapes (J. Kewisch)

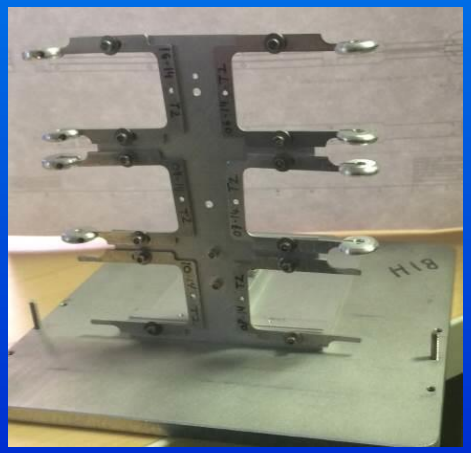


FY14



Tested with gold (outside) and helium beam with round shape (easier to make) 1" fins wshowed reduction of light

FY15



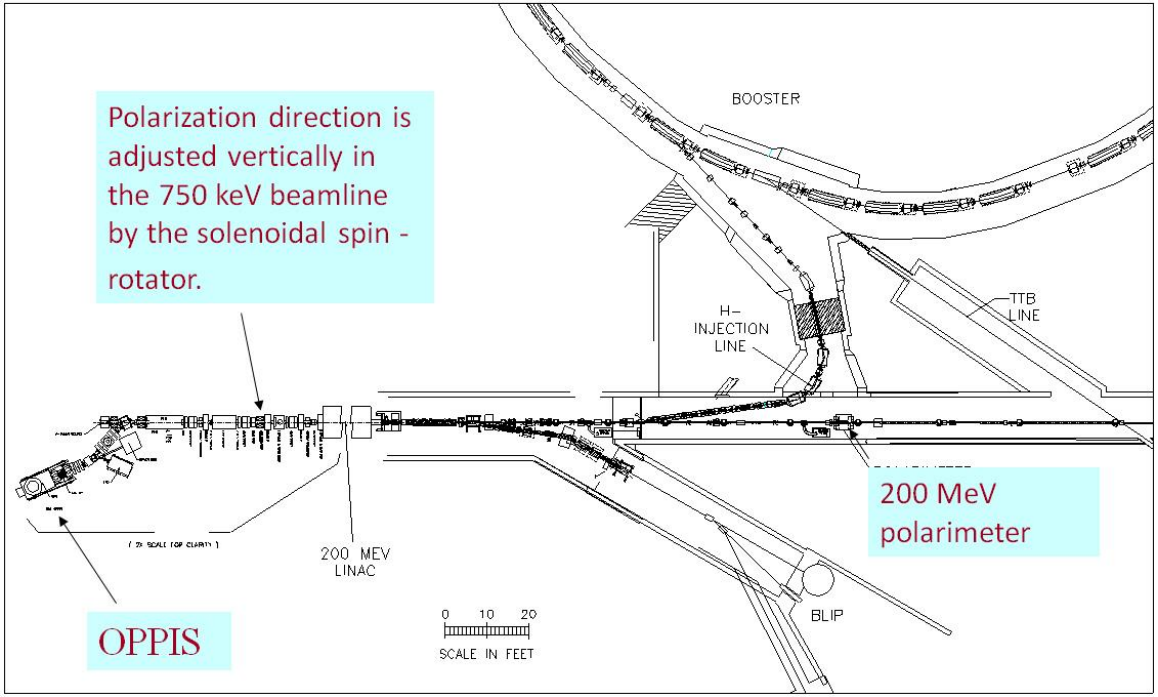
Smaller, round shape (0.5") fins providing a clear path for C-recoils to reach Si detectors.

FY15

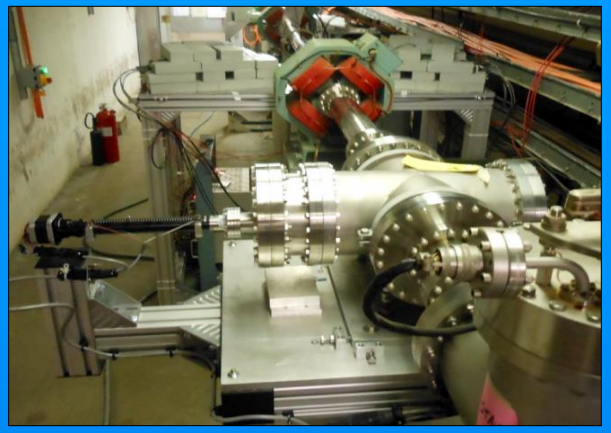
new Si detectors

H. Huang et al

Polarized injector, 200 MeV linac and injection lines.

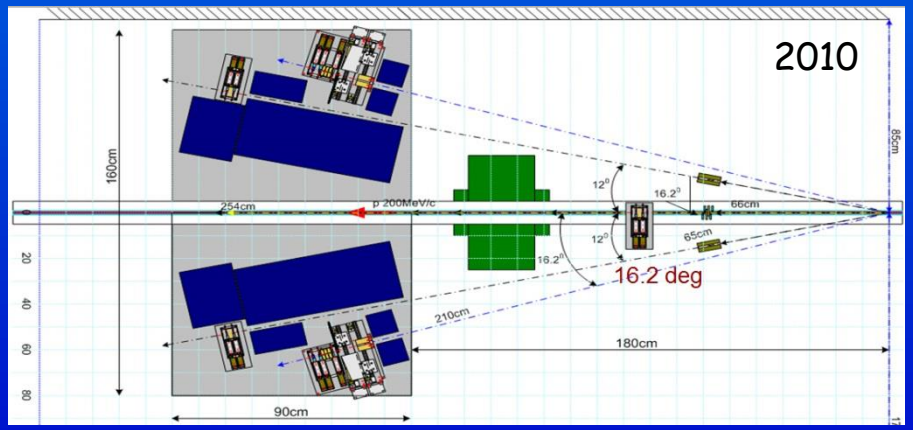


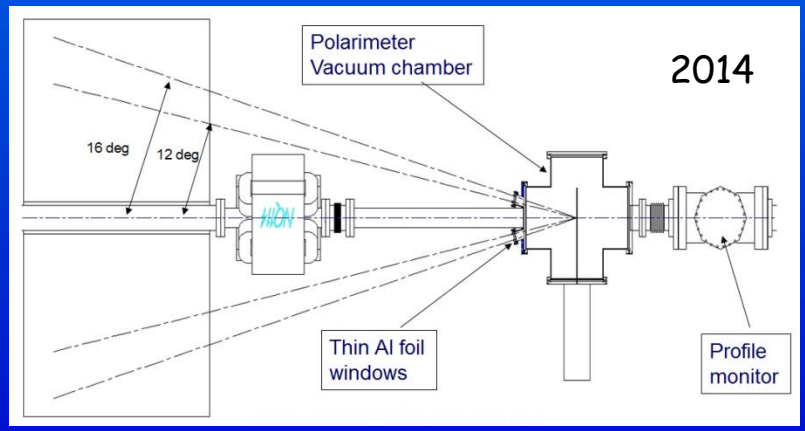
From RHIC Weekly meeting (06/16/14), A. Zelenski



Target station upgrade
- new linear target drive
- new motor and controller
- SLD to ADO conversion

A. Zelenski et al



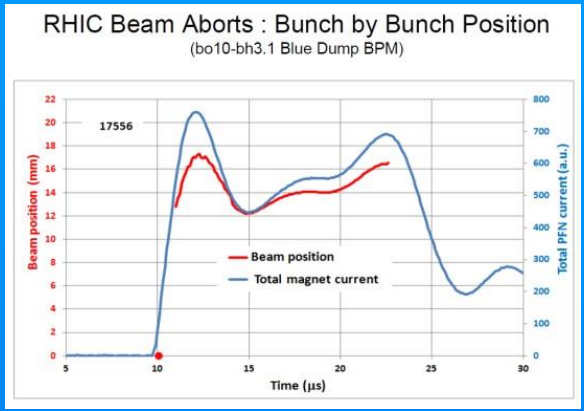


Upgrades for higher beam power: RHIC abort kicker upgrade

Issue — quenches caused by beam abort

Observations — measured kicker currents different (during operations and maintenance days)

measured abort kicker currents did not track (fast-sampled) beam position



Diagnosis — change in ferrite inductance with beam-induced temperature rise

FY15: new ferrites, additional cooling, new heat sinks, new feedthroughs, addition of local thermocouples

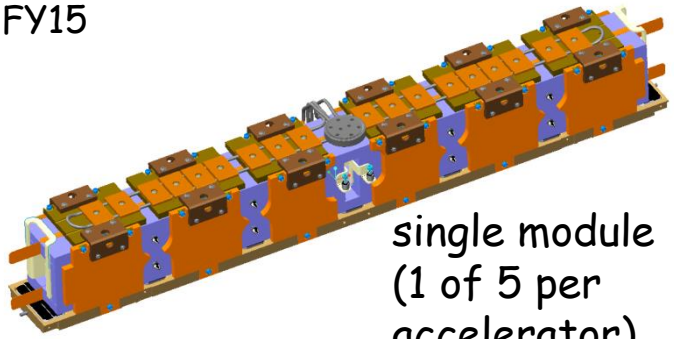
C. Pai et al

CERN-style low sensitivity BLMs

CERN BLMS detectors

CERN BLMS internal secondary emission electrodes

FY15



single module (1 of 5 per accelerator)

Upgrades for higher beam power: RHIC beam dump upgrade

design assumptions: E_{max} = 200 kJ at 100 GeV/A with N_b=60, N_{ppb}=1E9 (Au)

concern: secondary particle emission from dump absorber could heat and quench downstream superconducting magnets

Calculation of mechanical and thermal stress in the RHIC beam dump windows

S. Nayak, K. Yip, L. Ahrens, C. Montag

March 30, 2012

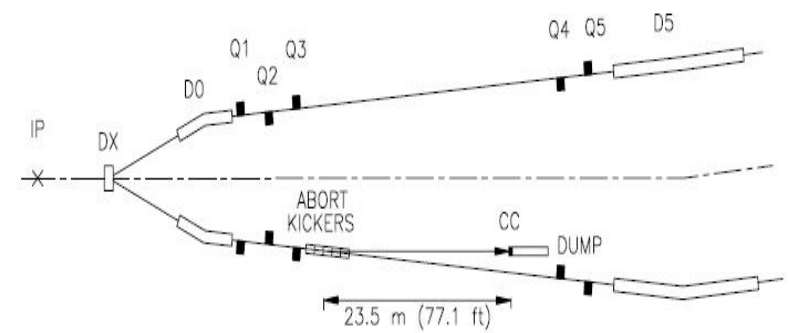


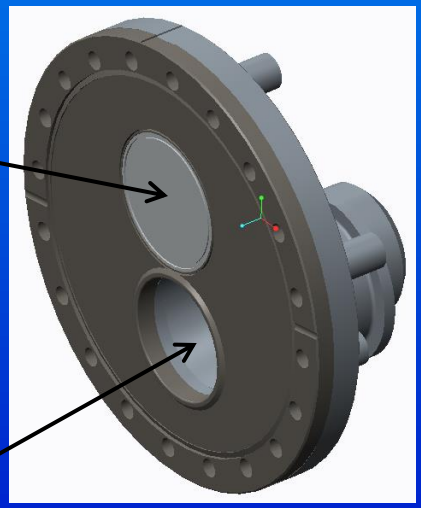
Fig. 6-1. Location of abort kickers and beam dump in the yellow ring at 10 o'clock.

Proposals: additional vertical abort kicker

use of Titanium alloy window by P.Thieberger (adopted)

Comparison of candidate material properties for the dump window	steel 17-7 PH	Ti 6242	
elastic modulus [GPa]	197	115	⇐ 1.7
Poisson's ratio	0.29	0.32	
yield stress [MPa]	940	960	⇐ 1.0
ultimate stress [MPa]	1289	1016	
therm. cond. [W/m · K] (0-100°C)	16.4	7.1	
therm. cond. [W/m · K] (500°C)	21.8	21.8	
therm. exp. coeff. [μm/(m · K)]	12	8.1	⇐ 1.5
specific heat [J/(kg · K)]	460	460	⇐ 1.0
melting point [°C]	1400	1700	
density kg/m^3	7800	4540	

Titanium 6242 room temperature advantage: 1.5 x 1.7 = 2.55



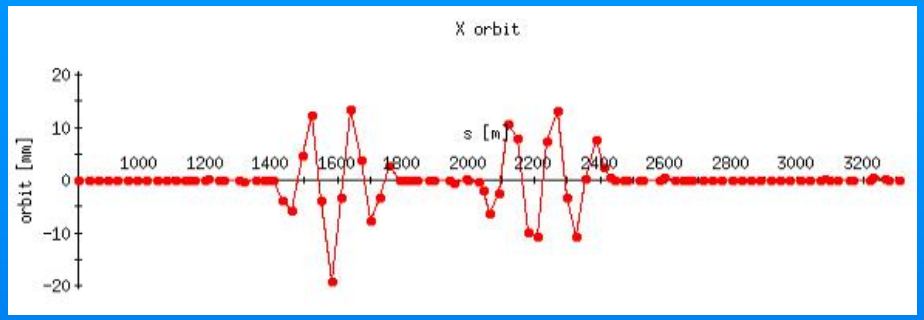
(circulating beam path)

S. Nayak et al

Upgrades for higher beam power: new RHIC masks

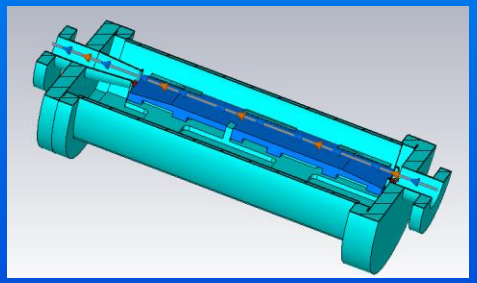
Issue — damage to experiment's detectors (esp. STAR) with kicker pre-fire

Remedy - FY14 — move beam towards aperture so that pre-fire deposits beam upstream

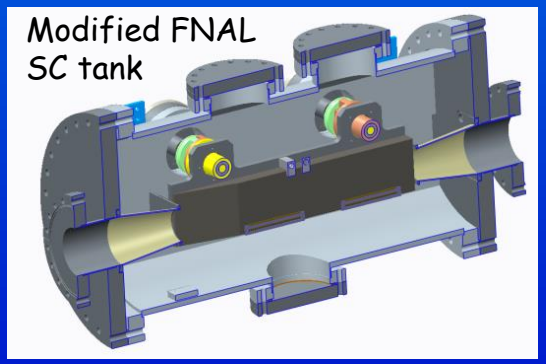


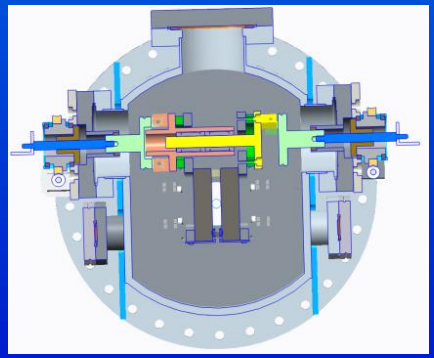
Issues (FY14) — pre-fire induced quenches and network upsets

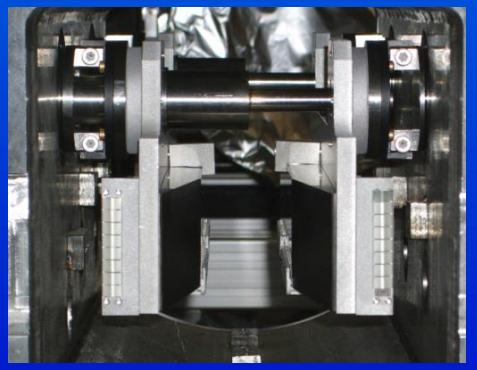
The New Mask Assembly for FY15



Beam-induced power dissipation was shown to be acceptable with Particle Studio simulations performed for all materials considered. The suggested titanium alloy and a tapered mask were adopted and allowed reducing the total number of jaw systems from four to two. Installations planned for Blue (sector 11), Yellow (sector 8)

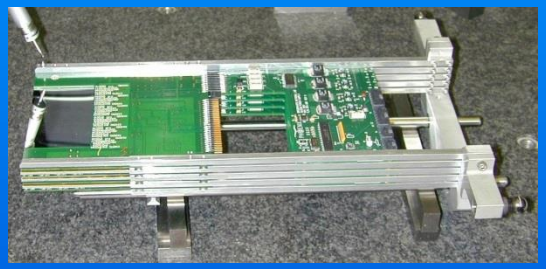






A. Drees, C.J. Liaw, D. Gassner, V. DeMonte, L. Desanto, W. Fu, D. Lehn, C. Montag, P. Thieberger, K. Yip

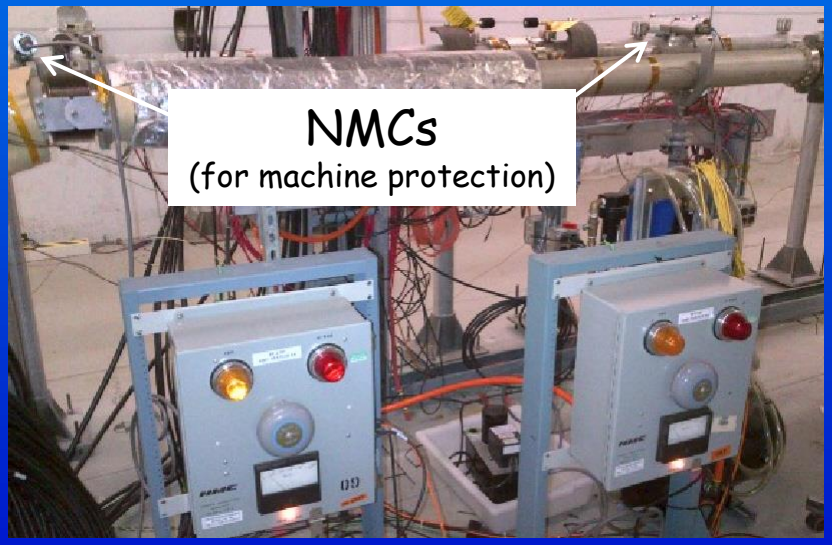
Roman Pot upgrade (for continuous non-dedicated mode operation in FY15)



FY09/12: 2 horizontal
2 vertical per sector

FY15: 2 vertical pairs
per sector
relocated closer to STAR

Detector package
placed inside the
Roman Pot

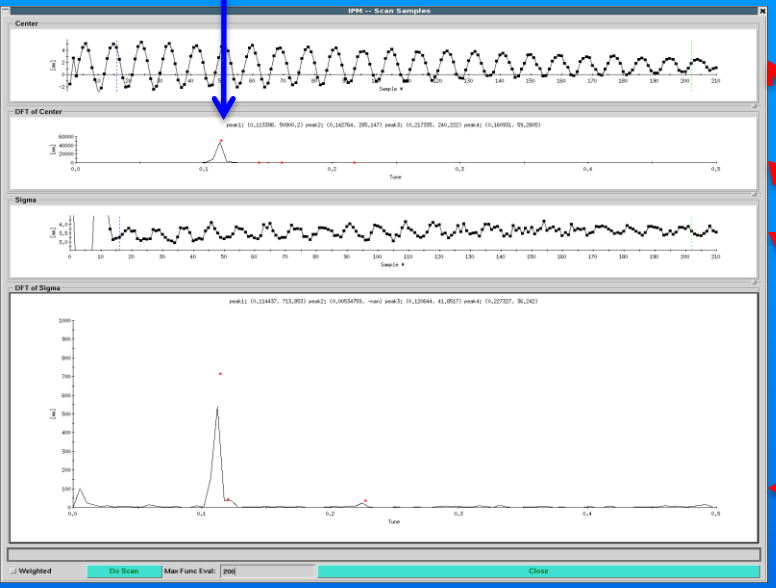


G. Wlodek et al

AGS e-IPMs

R. Connolly et al

Tune peak



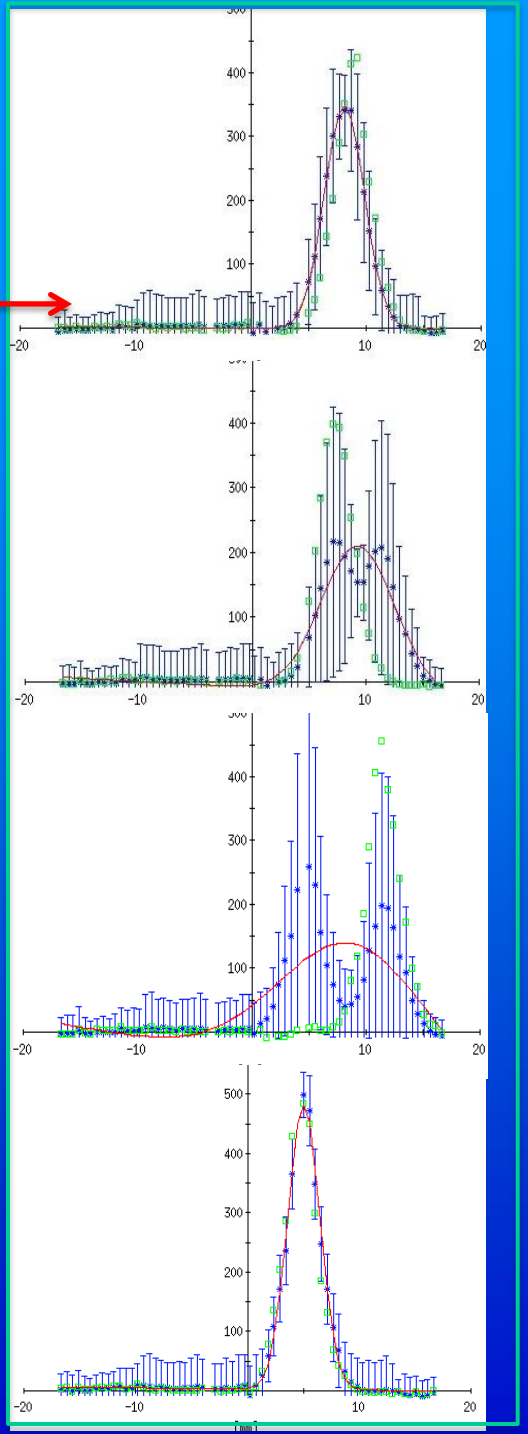
centers

FFT of centers

widths

FFT of widths

Vertical eIPM record of beam up ramp (5/30). Between t=532ms and t=582ms the beam started and stopped oscillating. Each profile record is the average of 200 turns.



TBT record of vertical beam at injection. 210 turns

New amplifiers are installed for Run 15

In FY13 we used the RHIC low-BW amps. These gave a running two-turn average.

In FY14 we used the fast amps. These were designed for the 5ns bunches of RHIC. They did not integrate the 200ns bunches of AGS and were sensitive to noise up to ~70MHz.

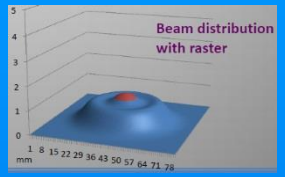
For FY15 we replaced the fast hybrid boards with charge-sensitive amps. These integrate charge pulses up to 200ns and completely decay in the 2.7μs revolution period.

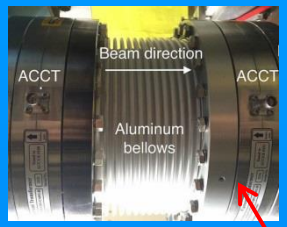
Bench test: input (top), output

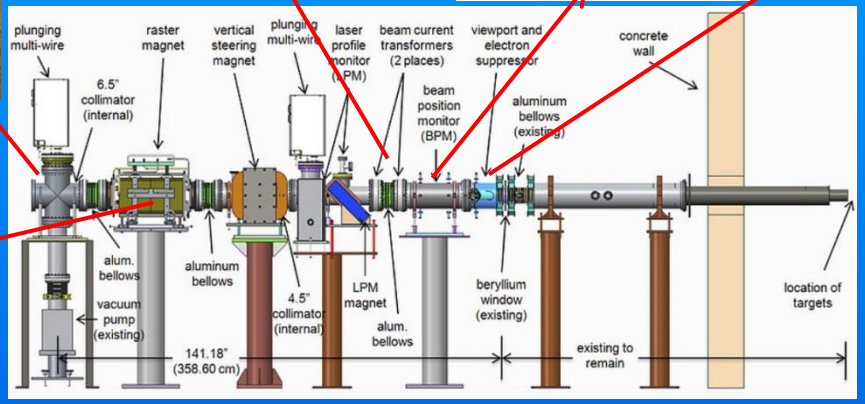
Instrumentation for other Beam Tests : BLIP raster upgrade

R. Michnoff et al

Fast-tracked project to reduce peak power density on target



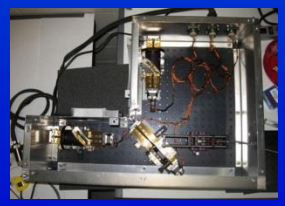


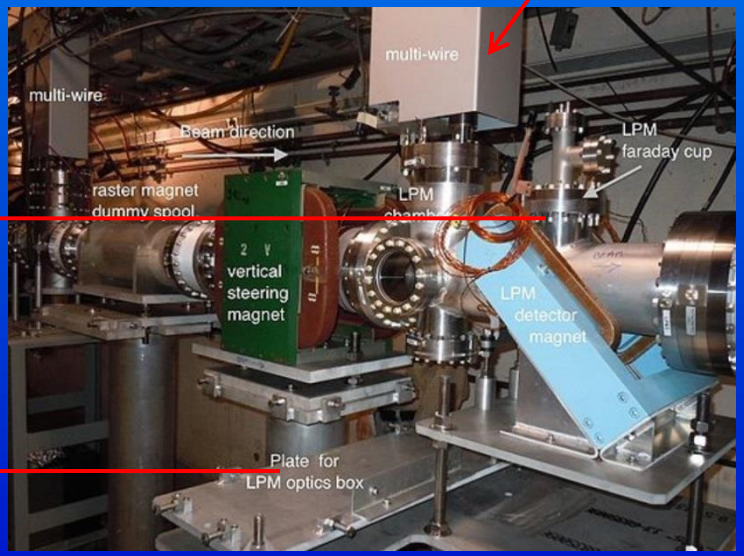


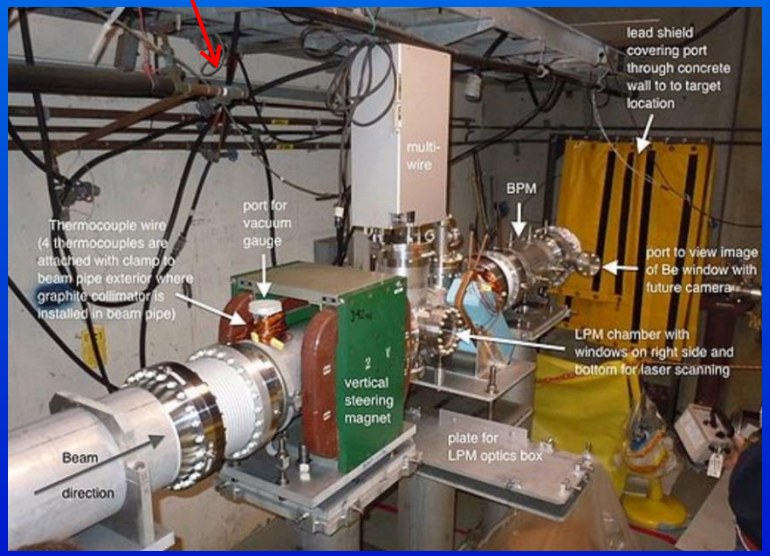
FY15:

- 2 plunging profile monitors
- 1 laser profile monitor
- 2 beam current transformers
- 1 beam position monitor
- collimators
- raster controls
- interlocks

FY16: install raster magnet





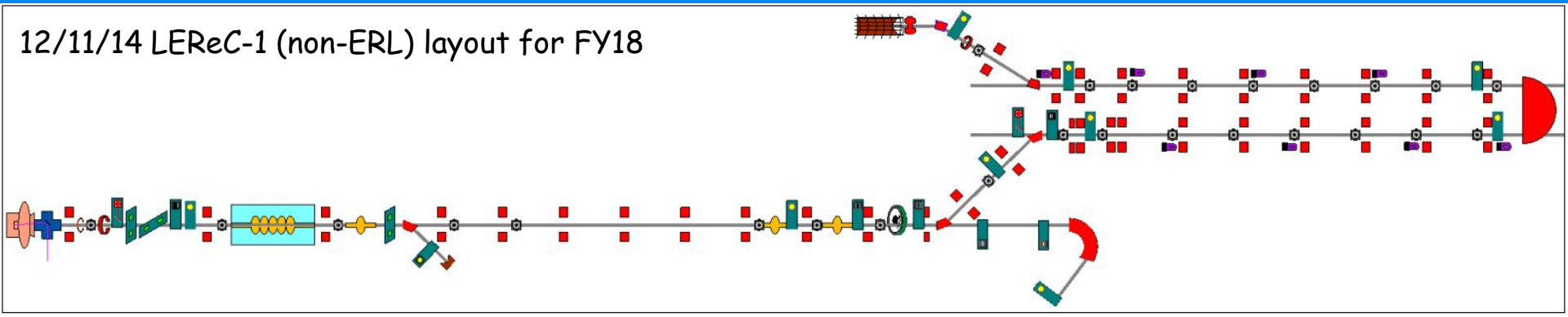


see also http://www.cadops.bnl.gov/Instrumentation/InstWiki/index.php/BLIP_Raster_Photos

Instrumentation for other Beam Tests : LEReC

11/17/14	first (non-dark current) beams demonstrated at BNL ERL
1/15	ERL GtD (gun-to-dump) commissioning planned
2/15	ERL recirculating beam
7/15 - 6/16	ERL high-current commissioning
7/16 - 3/17	subsystem relocation to RHIC for LEReC
10/17	FY18 run start

12/11/14 LEReC-1 (non-ERL) layout for FY18



Instrumentation Procurement & Repurpose

Item	Existing in ERL	Quantity needed For LEReC	Purchase total for LEReC
Beam Profile Monitors - low energy	5	11	6
Beam Profile Monitors - high energy	0	3 (or 1)	3 (or 1)
Multi-Slit - transverse emmitance	0	3	3
Beam Current Monitors - ICT	1	1	0
Beam Current Monitors - FC electronics	2	2	0
Beam Current Monitors - DCCT	2	2	0
Beam Loss Monitor - PMT	14	14	0
Beam Loss Monitor - Heliax	5	5	0
Beam Loss Monitor - Heliax (dump only)	24	24	0
Beam Loss Monitor - Thermal camera	1	1	0
Beam Loss Monitor - pin diode	8	8	0
Beam Position Monitors - dual-plane button cube, Libera electr.	14	10	0
Beam Position Monitors - 28mm dual-plane button cube, BNL elctr.	0	16	16
Beam Position Monitors – for ions in cooling section – BNL electr.	0	16	16
Beam Halo Monitors	6	6	0
Recombination Monitors (in cooling section)	0	4	4
RF cavity tuners & motion control	3	6	3
Totals	85	132	48

work in progress

Large quantity of new electron-beam diagnostics
- to be commissioned (at ERL) and implemented for LEReC
- to be yet procured

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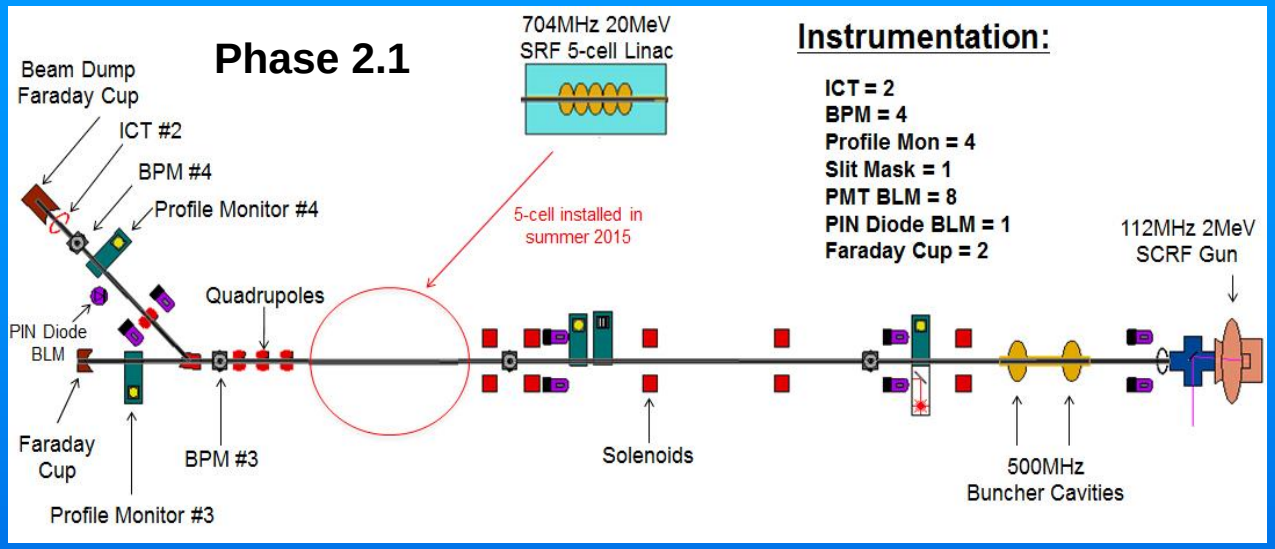
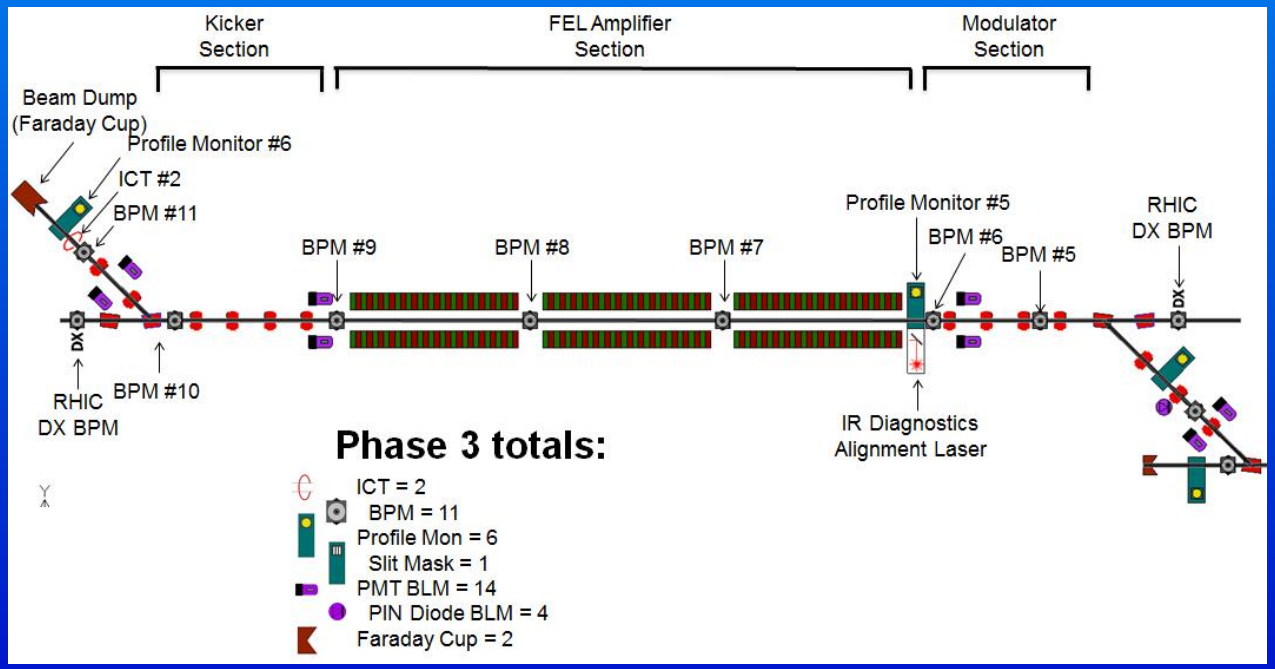
Instrumentation for other Beam Tests : CeC PoP





12/4/14 design gun voltage demonstrated

phase 2.1 commissioning with beams to commence using RHIC cryo

ELECTRON BEAM PARAMETERS	
Energy	2 & 22 MeV
Charge per bunch	0.5 – 5 nC
Electrons per bunch	3 – 6x10^9
E-beam current (1nC)	78 μA
Repetition rate	78 kHz
RMS Normalized Emittance	< 5 mm•mrad
RMS energy spread	<1x10^{-3}
RMS bunch length	10 psec
RMS transverse beam size	1 mm
E-beam power	1.7 kW

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Summary

E-Lens	electron backscattering detector monitoring of the electron beam longitudinal profile new instrumentation wheel new transverse bunch-by-bunch dampers
Polarimetry	RHIC jet, RHIC CNIs, 200 MeV polarimeter
Upgrades for higher beam power	new RHIC masks RHIC abort kicker upgrade RHIC beam dump upgrade
pp2pp and Roman Pot upgrade	
AGS e-IPMs	
Instrumentation for Beam Tests that will run in parallel - BLIP raster upgrade, ERL, CeC PoP are imminent - LEReC	

In addition to developments for E-Lens and higher beam power operation, this shutdown included significant investments in design, procurements, construction, etc. for future accelerator-based experiments at C-AD. Commissioning of new instrumentation at BLIP will start as early as tomorrow. Two test accelerators (ERL and the CeC PoP Linac) will operate in parallel with RHIC this year. Planning for the FY15 shutdown has started.